Geoscience Australia's Onshore Energy Security Program: Geothermal Energy

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Geoscience Australia's $58.9M 5-year Onshore Energy Security Program began in 2006 and included a new Geothermal Energy Project. The OESP concluded in June 2011 but the Geothermal Energy Section continues albeit with reduced funding.

The project aims to assist the development of a geothermal industry in Australia by: providing precompetitive geoscience information, including acquisition of new data; informing the public and government about Australia's geothermal potential; providing technical advice to government; and partnering with industry in international promotional events for the purpose of attracting investment.

This abstract gives a brief summation of activities undertaken by Geoscience Australia within the Onshore Energy Security Program potentially of interest to geothermal explorers.

Keywords: data acquisition, modelling, Geothermal Play Systems

Geothermal Energy Project

Following consultation with industry and State and Northern Territory geological surveys, a number of activities were identified where Geoscience Australia could either fill gaps where no other organisation was able to, or could complement activities by other partners.

Advice to government

Geoscience Australia (GA) is a prescribed agency within the Department of Resources, Energy and Tourism. GA provides advice to government on geoscience-related matters, including resources. GA participated in the development of the Geothermal Industry Development Framework and Geothermal Industry Technology Roadmap. GA was involved in the program design and subsequent technical assessment of the Geothermal Drilling Program. GA co-authored (with the Australian Bureau of Agriculture and Resource Economics) the Australian Energy Resource Assessment which included a chapter on geothermal energy. GA has been involved in the development of the Australian Code for Reporting of Exploration Results, Geothermal Resources and Geothermal Reserves, and sits on the Joint AGEA-AGEG Code Committee for the purpose of one day compiling and reporting geothermal resource and reserve estimates in the same way as is done for mineral and oil & gas commodities.

OzTemp

Geoscience Australia has released OzTemp, an updated dataset and map of predicted temperatures at 5 km depth, available from http://www.ga.gov.au/energy/geothermal-energy-resources.html. Extensive QA/QC was conducted on the dataset of bottom hole temperatures, and where available new data was included. For the map (Figure 1), the OZSeeBase dataset was used, and the Bureau of Metrology's Mean Annual Average Air Temperature was also used with a correction for surface temperature. For the first time, heat flow data was incorporated into the map.

Data acquisition

There is a paucity of temperature-specific data in Australia, and to address this Geoscience Australia has established a capability for measuring surface heat flow via thermal gradient logging and thermal conductivity measurement.

Thermal gradient logging

Without the possibility of drilling new holes, GA has worked with State geological surveys and minerals exploration companies to access exploration and water bores. Figure 2 shows the distribution of logged bores as of June 2011.

Thermal conductivity

Geoscience Australia operates an Anter 2022 Unitherm thermal conductivity meter and associated sample preparation equipment. Project staff have been involved in establishing operating procedures for the instrument, a process which has included inter-lab comparison testing with Torrens Energy, Hot Dry Rocks Pty Ltd, and Southern Methodist University. In addition, GA has engaged Hot Dry Rocks Pty Ltd to measure two batches of samples.

Samples have been taken from the majority of the bores measured for thermal gradient, as well as other bores for 'stratigraphic' conductivity values.

Heat Flow determinations

41 new heat flow determinations have been completed during the Program, providing a significant increase to the number of publicly

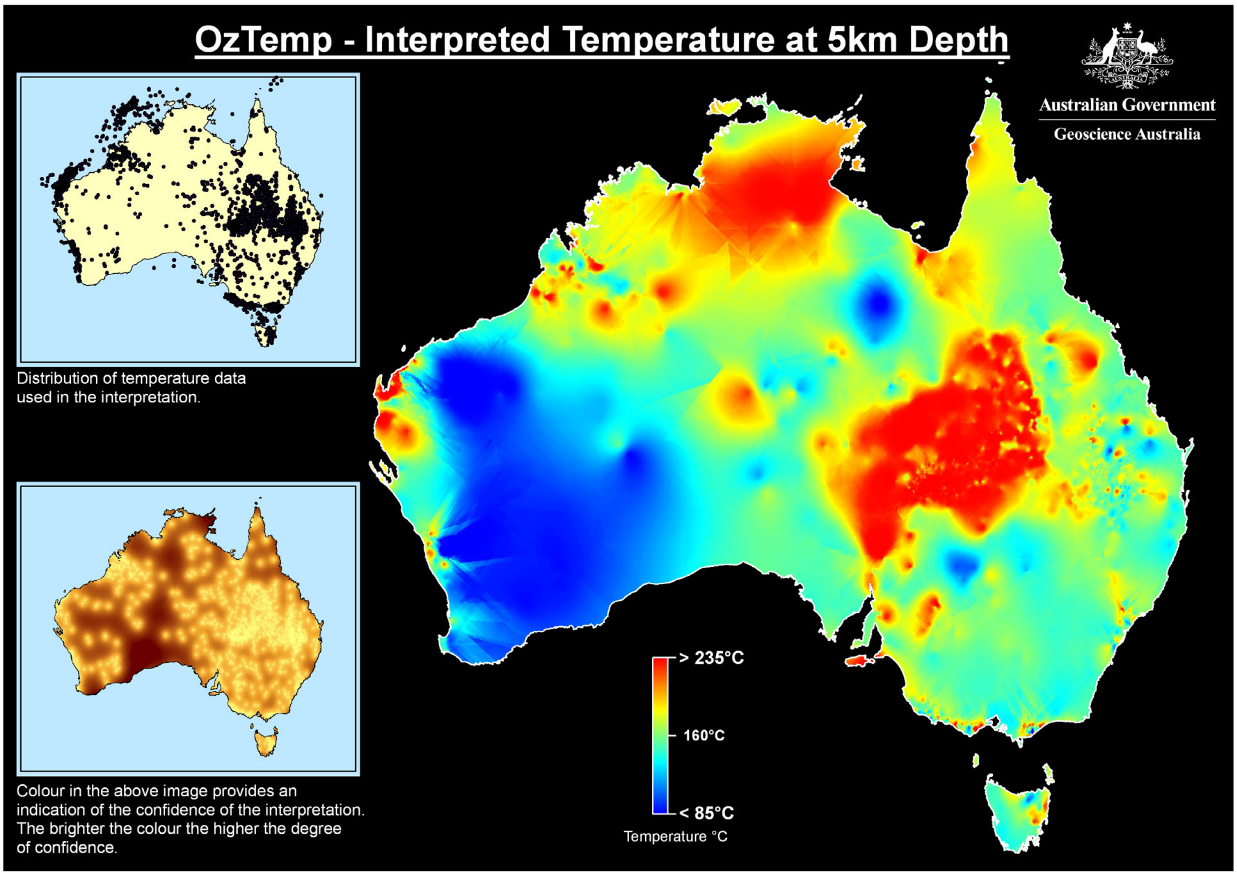

Figure 1: OzTemp map. An interpretation of the crustal temperature at 5km depth, based on the OzTemp bottom hole temperature database and additional confidential company data. A simple two layer model has been used for the extrapolation of the temperature to 5km depth; where the data quality and availability has allowed a slightly more complex three layer model using heatflow and thermal conductivity data was used for the extrapolation.

available heat flow data points. These determinations have been published in three Geoscience Australia records (Kirkby et al. 2010; Jones et al., 2011; Weber et al., 2011).

Promotion

Undoubtedly the greatest impediment to the development of the Australian industry since the Global Financial Crisis has been the lack of capital investment. Geoscience Australia has participated in "Team Australia Geothermal" events at the Geothermal Energy Expo (Reno 2009, Sacramento 2010 and San Diego 2011), and the World Geothermal Congress, Bali 2010. The collaboration of industry, government and associations has been aimed at portraying Australia as a favourable investment destination.

Resource assessments

In 2007 GA produced an estimate of the contained heat above 150°C in the top 5 km of the Australian crust. Understandably this produced a very large estimate of energy. To provide a degree of relevance and believability, an assumption was made that 1% of the resource would be accessible and convertible, and this therefore equates to ~26,000 years of energy consumption (Budd et al. 2008).

The production of the Australian Energy Resource Assessment (Geoscience Australia and ABARE, 2010) highlighted the need for a better understanding of Australia's geothermal resources potential. The knowledge of several other renewable energy resources is quite advanced, and there is a need for geothermal to be better understood so that it can be compared more directly to other energy sources. With a limitation on the availability of temperature data, other geoscience datasets must be used to inform or derive estimates of geothermal resource potential.

Geothermal Play Systems

It was mentioned above that there is a paucity of temperature-specific data publicly available in Australia. There is, however, a wealth of high-quality geoscientific data available throughout the country, much of which can be used to make assessments of geothermal potential from a conceptual view point. As have some companies and other organisations, GA has developed 2.5D and 3D methods for processing geological, geophysical and geochemical data to produce resource potential assessments and estimates. A 'systems' approach has been utilised to enable

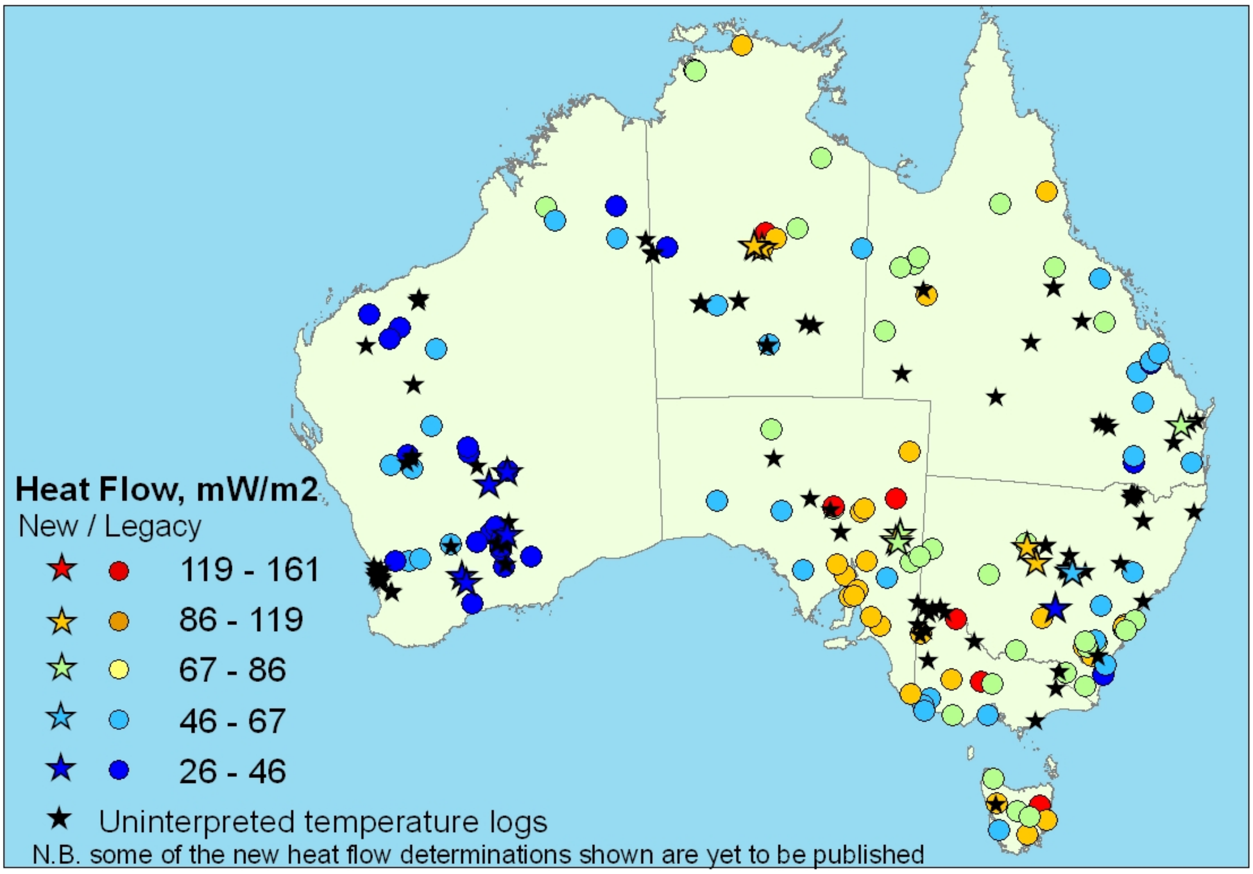

Figure 2: Heat flow data; published data in coloured circles; new data acquired by GA during OESP in stars.

these data sets to be used as ‘mappable proxies’ to estimate heat production and thermal insulation at regional scales (Budd et al. 2009). Conceptual and empirical methods of developing the Geothermal Play Systems approach have been pursued, and are still in further development.

3D thermal modelling

Through a Primary Industries and Resources South Australia (PIRSA) Australian Geothermal Energy Group (AGEG) Technical Interest Group 9 Tied Grant, a thermal calculation module for GeoModeller software was built by Intrepid Geophysics (e.g. Siekel et al. 2009). This has been used to develop thermal models of the Millungera Basin (Korsch et al., 2011), and the Cooper Basin (e.g. Gibson et al., 2010).

We have developed a synthetic grid of granites buried in flat-lying sediments that allows testing the effect of changing one variable at a time – the variables including thermal conductivity, density, heat production, and thickness of both granites and sediments, and additionally granite radius, granite thickness, and granite burial depth. This has resulted in 5,400 individual test models, and we are in the process of interpreting these results. These interpretations will then serve as a guide for a first-pass assessment of thermal potential of the whole content based on estimates of granite size and basin geometry and composition.

Energy Assessment

A GIS-based approach was used to qualify the Hot Rock and Hot Sedimentary Aquifer geothermal systems of northern Queensland (Huston, 2010).

A 3D thermal modelling approach was used to complete an assessment of geothermal potential in central-eastern South Australia (Huston and van der Wielen, 2011).

Seismic Acquisition and Processing

Geoscience Australia has more than 40 years experience in land seismic surveys and since 1980 has acquired in excess of 15 000 km of onshore deep crustal seismic reflection data and numerous 2D seismic refraction profiles. Since 2007, 13 seismic programs have been conducted through the OESP and ANSIR (see Figure 3) and the results of these surveys are being released progressively. Table 1 lists these surveys, their length, the data types acquired and the planned dates for release of the processed data.

Details of these surveys, and links to the results and interpretations can be found at http://www.ga.gov.au/minerals/projects/current-projects/seismic-acquisition-processing.html

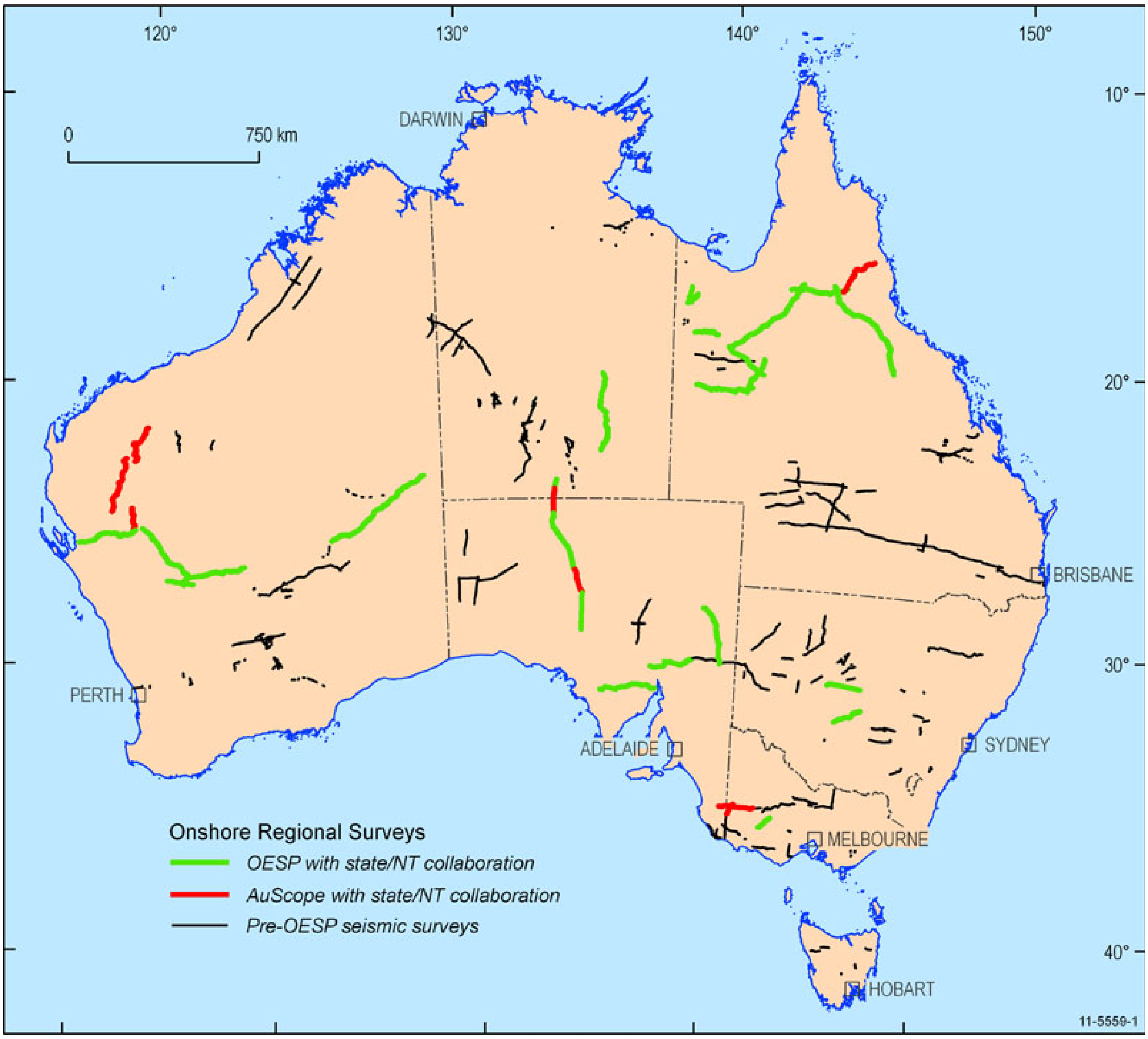

Figure 3. Map of Australia featuring seismic survey lines completed with OESP funding.

National Geochemical Survey of Australia

The primary aim of the NGSA is to provide pre-competitive data and knowledge to support exploration for energy resources in Australia. In particular, it will improve the existing knowledge of the concentrations and distributions of energy-related elements such as uranium (U) and thorium (Th) at the national scale.

The NGSA was initiated because of the realisation that there was no complete geochemical coverage available for Australia and because such a data layer is fundamental to successful exploration for energy-related and other commodities.

The objectives of the NGSA project are to:

- collect transported regolith samples at the outlet of large catchments covering more than 90 per cent of Australia using an ultra low sampling density approach;
- prepare and analyse the samples to extract the maximum amount of geochemical information (more than 60 elements) using internally consistent, state-of-the-art techniques;
- populate the national geochemical database with the resulting new data; and
- compile an atlas of geochemical maps for use by the exploration industry to identify areas of interest in terms of energy-related resources and other mineral commodities. These areas can then be the focus of targeted exploration efforts.

A sampling method has been adapted to Australian landscapes and climate conditions. It has been field-tested in the Riverina, Gawler and Thomson pilot projects. The cost of a national survey is kept reasonably low by applying an ultra low sampling density approach (1 site/1000 square kilometres to 1 site/10 000 square kilometres).

Details of these surveys, and links to the results and interpretations can be found at http://www.ga.gov.au/energy/projects/national-geochemical-survey.html.

Australia-Wide Airborne Geophysical Survey II

A common problem with past national airborne geophysical coverages is that the surveys were flown in patchwork fashion over many years and are not all registered to the same datum. In the case of airborne gamma-ray spectrometric data, acquisition equipment, system calibration and data processing procedures have changed significantly over time. Older surveys in Australia were reported in units of count per second, while modern surveys are reported in units of radioelement concentration. Also, environmental effects such as soil moisture and radon emanation can affect the base level of gamma-ray surveys. This means that gamma-ray spectrometric surveys seldom match exactly along their common borders, making it difficult to merge surveys into regional or continental-scale compilations. This limits the usefulness of these data because regional compilations facilitate the interpretation of large-scale features in the data and the comparison of features large distances apart.

A similar problem occurs with magnetic surveys, with inadequate reference field removal introducing base-level shifts. Also, the cross-over tie levelling procedure commonly applied to airborne magnetic data introduces a range of spurious wavelengths into the levelled data. Both gamma-ray spectrometric and magnetic surveys can be levelled and merged into continental-scale compilations by using the differences in areas where the surveys overlap to estimate correction factors. However, without independent control, this merging procedure can introduce long-wavelength errors into the merged data.

The Australian Government's solution to this problem was to acquire gamma-ray spectrometric and magnetic data over the entire Australian

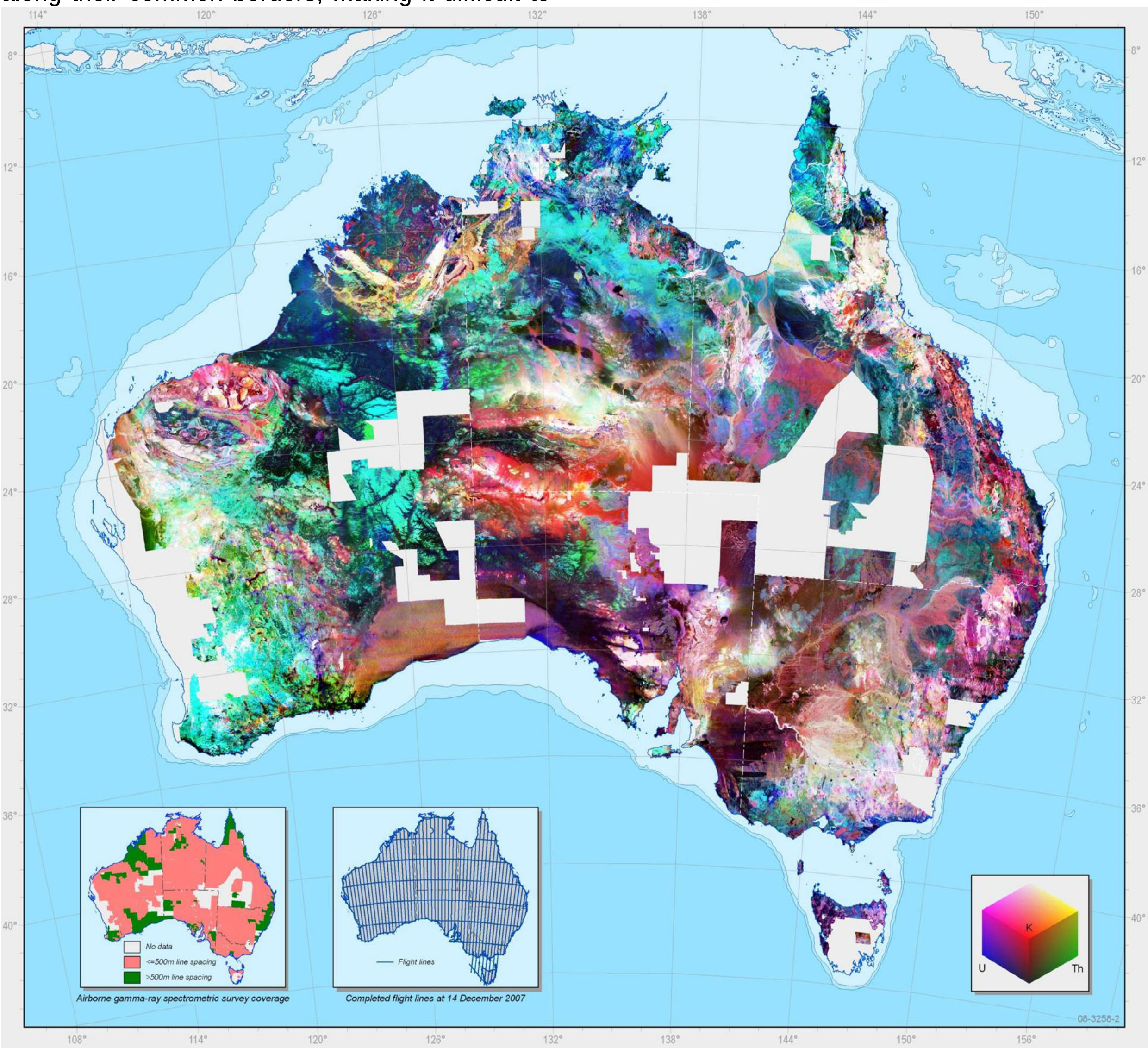

Figure 5: The new Radiometric Map of Australia (2010) has been compiled showing the distribution of airborne measured potassium (percent K), uranium (ppm equivalent U) and thorium (ppm equivalent Th) over 80 percent of the Australian continent at 100 metre resolution

continent at 75 km flight line spacing. These data (the Australia Wide Airborne Geophysical Survey - AWAGS) have been used to level and merge all public-domain gamma-ray spectrometric and magnetic data in Australia to common datums. The gridded merged data have been called the Radiometric and Magnetic Maps of Australia, respectively.

Project outputs

AWAGS survey

The AWAGS survey was completed in June 2008, and the project is continued as part of the Continental Geophysics Project. The data are available via the Australian Government's Geoscience Portal Geophysical Archive Data Delivery System (GADDS).

Radiometric Map of Australia

A new radioelement map of Australia, the Radiometric Map of Australia, has been compiled showing the distribution of airborne measured potassium (percent K), uranium (ppm equivalent U) and thorium (ppm equivalent Th) over 80 percent of the Australian continent at 100 metre resolution (Minty et. al., 2009). The map has been calibrated with the AWAGS to adjust all the public-domain radiometric surveys in Australia to the International Atomic Energy Agency's (IAEA) Global Radioelement Datum. The new datum provides a baseline for all current and future airborne gamma-ray spectrometric surveys in Australia.

Interpreters can use these grids of potassium, equivalent thorium and equivalent uranium to reliably compare the radiometric signatures observed over different parts of Australia. This enables the assessment of key mineralogical and geochemical properties of bedrock and regolith materials from different geological provinces and regions across the continent. These data support a range of different applications, including geological mapping, mineral and petroleum exploration, geomorphological studies and environmental mapping.

Magnetic Anomaly Map of Australia

A 5th edition full-colour Magnetic Anomaly Map of Australia at 1:5 million scale, and accompanying composite dataset with cell resolution of 3 seconds of arc, have been compiled. It is estimated that 27 million line-kilometres of survey data was acquired to produce this new edition, which is eight million line-kilometres more than for the previous edition released in 2004. New independent airborne total-field magnetic data acquired in 2007 during the AWAGS have been used to increase the accuracy of intermediate wavelengths of the continental-scale merge of the grids.

Information in the new magnetic anomaly map and associated grid database provides insights into the distribution of magnetically susceptible minerals within the Earth's crust. Such insights are of great value to energy and mineral exploration companies and for research into the solid Earth and the environment. Magnetic minerals in small amounts are widespread in the crust and become concentrated in zones which highlight the structure of the crust. This is particularly important for areas that have a significant thickness of surface cover (regolith and sedimentary basins) which can mask the underlying crystalline basement rocks. The magnetic signatures of the basement are measured through the cover and provide important information to help determine the nature and depth of the basement.

Details of these surveys, and links to the results and interpretations can be found at http://www.ga.gov.au/energy/projects/awags.html.

Conclusion

Precompetitive geoscience data can underpin investment decisions by both geothermal explorers and developers, and government.

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Table 1. Sesimic reflection surveys acquired through the OESP.

Stakeholders	Survey Name	State	Traverse No	Length	Data Types	Survey Completed	Processed Data Release
OESP, GSQ Zinifex/pmd* CRC	L180 Mt Isa	Qld	06GA-M1	75km	Reflection, Gravity	Oct-07	Jun-08
		Qld	06GA-M2	62km	Reflection, Gravity	Oct-07	Jun-08
		Qld	06GA-M3	121km	Reflection, Gravity	Oct-07	Jun-08
		Qld	06GA-M4	200km	Reflection, Gravity	Dec-07	Jun-08
		Qld	06GA-M5	160km	Reflection, Gravity	Dec-07	Jun-08
		Qld	06GA-M6	283km	Reflection, Gravity	Nov-07	Jun-08
OESP/GSQ	L184 Isa-Georgetown	Qld	07GA-IG1	440km	Reflection, Gravity, MT	Aug-07	Dec-08
		Qld	07GA-IG2	243km	Reflection, Gravity, MT	Aug-07	Jun-09
OESP/GSQ	L185 Charters Towers	Qld	07GA-GC1	493km	Reflection, Gravity, MT	Sep-07	Jun-09
AuScope	L186 AuScope	Qld	07GA-A1	205km	Reflection, Gravity	Sep-07	Jun-09
OESP/NSW-DPI	L188 Rankins Springs	NSW	08GA-RS1	127km	Reflection, Gravity	Mar-08	Oct-08
		NSW	08GA-RS2	107km	Reflection, Gravity	Mar-08	Oct-08
	L188 Rankins Springs Extension (includes Line 08GA-RS2)	NSW	09GA-RS2	138km	Reflection, Gravity	Feb-09	Jun-09
OESP	L189 Gawler-Curnamona-Arrowie (Gawler province)	SA	08GA-G1	253km	Reflection, Gravity, MT	Jun-08	Dec-09
	L189 Gawler-Curnamona-Arrowie	SA	08GA-A1	60km	Reflection, Gravity	Jun-08	May-09

	(Arrowie Basin)						
	L189 Gawler-Curnamona-Arrowie (Curnamona province)	SA	08GA-C1	262km	Reflection, Gravity, MT	Jul-08	Sep-09
OESP/ AuScope/	L190 Gawler-Officer-Musgrave-Amadeus	SA/NT	08GA-OM1	634km	Reflection, Gravity, MT	Dec-08	Jul-10
PIRSA							
OESP/PIRSA	L191 Curnamona-Gawler Link	SA	09GA-CG1	144km	Reflection, Gravity	Jan-09	Jan-10
OESP/NTGS	L192 Georgina - Arunta	NT	09GA-GA1	373km	Reflection, Gravity, MT	Jul-09	Jan-11
AuScope/GSV/OESP	L193 Southern Delamerian	Vic/SA	09GA-SD1	146km	Reflection, Gravity	Nov-09	Jan-11
		Vic/SA	09GA-SD2	51km	Reflection, Gravity	Nov-09	Jan-11
GSV/OESP	L194 Ararat	Vic	09GA-AR1	69.6km	Reflection, Gravity	Nov-09	Jan-11
AuScope/GSWA/OESP	L195 Capricorn	WA	10GA-CP1	198km	Reflection, Gravity	May-10	Mid 2011
		WA	10GA-CP2	276.8km	Reflection, Gravity	May-10	Mid 2011
		WA	10GA-CP3	106.4km	Reflection, Gravity	May-10	Mid 2011
GSWA/OESP	L196 Youanmi	WA	10GA-YU1	302.2km	Reflection, Gravity, MT	Aug-10	Late 2011
		WA	10GA-YU2	282.8km	Reflection, Gravity, MT	Aug-10	Late 2011
		WA	10GA-YU3	109.8km	Reflection, Gravity, MT	Aug-10	Late 2011